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| 09/499,037      | 02/07/2000  | Kazuhiro Aihara      | 49657-551           | 9656             |

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EXAMINER  
MONDT, JOHANNES P

|          |              |
|----------|--------------|
| ART UNIT | PAPER NUMBER |
| 2826     |              |

DATE MAILED: 06/19/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

# Office Action Summary

Application No.

09/499,037

Applicant(s)

AIHARA ET AL.

Examiner

Johannes P Mondt

Art Unit

2826

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

## Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

## Status

- 1) ☒ Responsive to communication(s) filed on 12 March 2003.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

## Disposition of Claims

- 4) ☒ Claim(s) 1-16 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☒ Claim(s) 3-6, 14 and 16 is/are allowed.
- 6) ☒ Claim(s) 1, 2, 7-13 and 15 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

## Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved by the Examiner.  
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

## Priority under 35 U.S.C. §§ 119 and 120

- 13) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All b) ☐ Some \* c) ☐ None of:
1. ☒ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

## Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) \_\_\_\_\_
- 4) ☐ Interview Summary (PTO-413) Paper No(s). \_\_\_\_\_
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: \_\_\_\_\_

## DETAILED ACTION

### ***Continued Examination Under 37 CFR 1.114***

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 03/12/03 has been entered as Paper No. 17.

### ***Response to Amendment***

Amendment D filed 03/12/03 has been entered as Paper No. 18 and forms the basis of this Office Action.

### ***Response to Arguments***

2. Applicant's arguments filed in Amendment D have been fully considered but they are not fully persuasive. In particular:

While the 112 rejections can be withdrawn, regarding Applicant's traverse of examiner's statement that the work function of tantalum nitride inherently is greater than 4.95 eV, the documents included in Applicant's Amendment D do not support Applicant's thesis for said traverse. In particular, the text by Goto et al is unacceptable at least because of its unpublished nature, while the publication by B.R. Rogers, Thin Solid Films, Volume 408, pp. 87-96 (2002) reinforces the examiner's opinion, because for the pure tantalum nitride surface a value of 5.15 eV for its work function is cited (cf. Table 2) while the sputtered surface has a different work function because it is no longer

pure tantalum nitride, but instead also contains aluminum (Al) (cf. section 4: "Discussion", in particular pp. 93-94, and Table 2), and hence is aluminum tantalum nitride instead of tantalum nitride. Furthermore, in addition to the already cited patent by Liang the examiner also herewith cites Barnak et al (US 2002/0008257 A1). Both Rogers and Barnak et al do not qualify under 35 U.S.C. 102 or 103 as prior art in view of their recent dates of publication and the early date of Applicant's filing. However, neither is a citation as prior art the objective, because given a material structure the work function is well defined.

### ***Claim Rejections - 35 USC § 102***

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

The changes made to 35 U.S.C. 102(e) by the American Inventors Protection Act of 1999 (AIPA) and the Intellectual Property and High Technology Technical Amendments Act of 2002 do not apply when the reference is a U.S. patent resulting directly or indirectly from an international application filed before November 29, 2000. Therefore, the prior art date of the reference is determined under 35 U.S.C. 102(e) prior to the amendment by the AIPA (pre-AIPA 35 U.S.C. 102(e)).

1. **Claims 1, 7-9 and 15** are rejected under 35 U.S.C. 102(e) as being anticipated by Choi et al (6,168,991 B1).

*On claim 1:* Choi et al teach a semiconductor device, comprising: a contact plug including a tungsten film 14 (cf. column 4, lines 3-10) in an upper portion of the contact plug, formed on a semiconductor substrate (dielectric layer 19 (cf. column 3, lines 43-44) is formed over the field effect transistor which is inherently formed on a semiconductor substrate, in this case inter alia through HDP (cf. column 3, lines 52-57) which is understood to involve formation on a semiconductor wafer); a storage electrode 20 (cf. column 4, lines 38-56) including a tantalum nitride film serving as a barrier against copper migration into the capacitor dielectric film 22, said tantalum nitride film being formed on and contacting an upper surface of said tungsten film; a capacitor dielectric film 22 (cf. column 4, lines 57-67) including a tantalum oxide film (cf. column 4, line 67) formed on and contacting an upper surface of said tantalum nitride film; a cell plate electrode 26 (cf. column 5, lines 20-33) including a tantalum nitride film (cf. abstract, sixth sentence) formed on and contacting an upper surface of said tantalum oxide film. Values for the work function in excess of 4.95 eV, - see in particular a statement that the work function of a tantalum nitride layer is 5.41 eV (cf. Liang et al (6,130,123), column 5, lines 26-28), are inherent for tantalum nitride films. Reports of the value of the work function may differ slightly, but a material that is characterized by its constitution has a given work function. The value of the work function of a tantalum nitride layer is simply a consequence of its constitution, as said value is a property of the structure of the tantalum nitride.

*On claims 8-9:* inherently the work function of the tantalum nitride film of claim 1 as anticipated by Choi is 5.41 eV.

*On claim 15:* the limitations of claim 15 are included in those of claim 1.

2. **Claims 2 and 10-12** are rejected under 35 U.S.C. 102(e) as being anticipated by Choi et al (6,168,991 B1). Please be referred to Figure 8. Choi et al teach a semiconductor device (cf. Field of Invention, column 1, lines 16-20), comprising: a storage electrode 20 (cf. column 4, lines 38-56) including a first tantalum nitride film (cf. column 4, line 39) formed over a semiconductor substrate (dielectric layer 10 (cf. column 3, lines 43-44) is formed over the field effect transistor which is inherently formed on a semiconductor substrate, in this case through HDP (cf. column 3, lines 52-57) which is understood to involve formation on a semiconductor wafer); a capacitor dielectric film 22 (cf. column 4, lines 57-67) including a tantalum oxide film (cf. column 4, lines 65-67) formed on and contacting an upper surface of said first tantalum nitride film; a cell plate electrode 26 (cf. column 5, lines 20-33) including a second tantalum nitride film (cf. abstract, sixth sentence) formed on and contacting an upper surface of said tantalum oxide film; and a copper film 28/30 (cf. column 5, lines 60-65 and column 6, lines 18-21) formed on and contacting an upper surface of said second tantalum film. Values for the work function in excess of 4.95 eV are inherent for tantalum nitride electrode films (see Liang et al (6,130,123), column 5, lines 26-30). See Liang et al (6,130,123), column 5, lines 26-30). In conclusion, Choi et al anticipate claim 2.

*With regard to claims 10-12:* the work function of the tantalum nitride film of claim 1 as anticipated by Choi is 5.41 eV.

***Claim Rejections - 35 USC § 103***

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

4. ***Claim 13*** is rejected under 35 U.S.C. 103(a) as being unpatentable over Choi et al (6,168,991 B1) in view of Kook et al (6,008,123). As detailed above, claim 1 is anticipated by Choi et al. Choi et al do not necessarily teach the further limitation as defined by claim 13. However, it would have been obvious to include said further limitation in view of Kook et al who teach the inclusion of a titanium / titanium nitride barrier layer 510 (cf. col. 5, lines 10-20) at the bottom of the tungsten contact plug 520 (cf. col. 5, lines 3-40) for the specific purpose to provide a tungsten diffusion barrier, i.e., so as to prevent the tungsten in the contact plug and the underlying semiconductor source and drain regions (cf. col. 3, lines 29-45) (see Figure 5). Motivation to include the teaching in this regard by Kook et al is the prevention of the diffusion of tungsten away from where it is needed (namely: in the contact plug). Combination of the teaching with the invention by Choi et al is straightforward by PVD and conventional processes as indicated by Kook et al (cf. col. 5, lines 15-21). Success of the implementation of said combination can therefore be reasonably expected.

***Allowable Subject Matter***

5. ***Claims 3-6, 14 and 16*** are allowed. The following is a statement of reasons for the indication of allowable subject matter: the invention by Kang (6,211,005 B1) has a strontium bismuth tantalum oxide layer included in the capacitor dielectric film that otherwise satisfies the limitations of claim 3, and hence also that part of the limitations of claims 4 and 5 that are identical with claim 3. However, it is not obvious to replace said strontium bismuth tantalum oxide with tantalum oxide, because ferroelectric materials such as strontium bismuth tantalum oxide have the advantage over tantalum oxide (including  $Ta_2O_5$ ) as dielectric material in a capacitor for a DRAM of having a higher dielectric constant. Claim 6 depends on claim 5 and also was disclosed. Claim 14 depends on claim 3 and is disclosed.

Other art of interest such as Summerfeldt et al (5,612,574) (Form PTO-892) does not teach direct contact between tantalum nitride layer 22 (cf. col. 4, line 5) and tungsten film 20 (cf. col. 3, line 45) because of an intervening adhesion layer 26 made of "titanium, tantalum, ruthenium or other suitable material", nor do Summerfeldt et al teach that the cell plate electrode can also be made of indium oxide. The latter omission to teach indium oxide for the cell plate electrode means that claim 16 is allowable.

***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Johannes P Mondt whose telephone number is 703-306-0531. The examiner can normally be reached on 8:00 - 18:00.



If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nathan J Flynn can be reached on 703-308-6601. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7724 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

JPM  
June 15, 2003

  
Minhloan Tran  
Primary Examiner  
Art Unit 2826